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PATENT APPLICATION

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August 27, 2003

John C. Hammar

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	J. Waldrop <i>et al.</i>	Group Art Unit:	1732
Application No.:	09/731,945	Examiner:	Staicovici
Filing Date:	Dec. 7, 2000	Docket No.:	99-113A
For:	<i>Double Bag Vacuum Infusion Process</i>		

Mail Stop Appeal Brief-Patents

P.O. Box 1450

Commissioner for Patents

Alexandria, VA 22313-1450

BRIEF ON APPEAL

Sir:

Applicant files three copies of this Brief on Appeal within three months following filing a Notice of Appeal on May 27, 2003. Please extend the time to respond one month and charge the fee of \$110.00 to Deposit Account 02-2960, making the total for this paper: \$430.00. Please also charge the fee of \$320.00 under 37 C.F.R. §1.17(f) for this brief to Deposit Account No. 02-2960. If Applicant owes any other fee (including any fees under §1.17 or all required extension of time fees), please charge that fee to Deposit Account 02-2960. Please treat this paper (and any future reply) as incorporating a petition for extension of time for the appropriate length of time, in the event that an extension is required.

I. REAL PARTY IN INTEREST

The real party in interest in this appeal is The Boeing Company.

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II. RELATED APPEALS AND INTERFERENCES

Applicant does not know of any other appeals or interferences that directly affect or will be directly affected by the Board's decision in this appeal. It resolved several 112 issues.

III. STATUS OF CLAIMS

1. Claims pending: 1, 2, 4 - 8, 10 - 12
2. Claims canceled: 3, 9
3. Claims withdrawn from consideration but not canceled: 2
4. Claims allowed: None
5. Claims rejected: 1, 4 - 8, and 10 - 12.
6. Claims on appeal: 1, 4 - 8, and 10 - 12

IV. STATUS OF AMENDMENTS

Applicant filed an Amendment After Final Rejection on August 21, 2003, which was entered.

V. SUMMARY OF INVENTION

As described on page 11 to page 15 of the application, the present invention is a liquid molding process and system for producing quality composite structures at low cost. It falls within the category of resin transfer molding (RTM), particularly vacuum-assisted RTM (VaRTM). The simple tooling, minimal capital requirements, batch processing capability, high yield, and capability to mold complex shapes make the process attractive. For making aerospace structure, it promises to be an economical process, especially suited for large structures, including wing boxes and the like. The present invention dovetails nicely with other enabling technologies such as stitching, Z-direction reinforcement (Z-pinning), electron beam curing, 3-D weaving, and low temperature curing. It does not require an autoclave, matched tooling, or large presses.

High vacuum integrity with a double bag system of our design helps to yield high quality composites consistently with low void content, minimal surface porosity, excellent thickness control, and high fiber volume fractions. The double bag improves stiffness of the bagging material to avoid relaxation behind the wavefront, thereby permitting the infusion of void-free composites having the high fiber volumes desired for aerospace applications. Controlling relaxation effectively means that we can use a higher differential pressure (DP) as the driving force for resin transfer. We can infuse faster or can use more viscous resins because of the larger driving force. We desire fiber volume fractions in excess of 50%.

Resin wave front control produces clean infusions without surface porosity, voids, dry spots, or resin rich zones. *Seemann* uses thick coarse flow media to direct resin to the underlying preform and bag offsets. The media and offsets create a highly permeable space for rapid resin migration laterally in the bag. The speed of infusion, however, can lead to trapped air or surface porosity defects or voids as the resin percolates down through the thickness of the preform. Lateral flow can exceed downward wetting of the preform, trapping air in pockets. Air trapped behind the wave front becomes difficult to remove from the infused part. Bubbling as air escapes can make it difficult to establish an end point for the infusion.

The key to successful infusions is not the speed with which the preform is infused, but rather the quality of the infusion. Maintaining a controlled wave front with lower permeability flow media over the preform gives cleaner infusions. The flow media we prefer to use should allow the resin to flow laterally slowly enough that the resin can uniformly drop down through the preform to wet out and completely fill the preform with a wedge shaped flow profile. In a controlled flow front, the resin front on the bag side of the preform is only 2 or 3 inches ahead of the resin front on the tool side of the preform assuming flow media is placed only on the bag side of the preform and infusion includes lateral flow through the media followed by downward flow to fill the preform. We prefer to control the relative permeability of the flow media to that of the preform to achieve this orderly, albeit relatively slow, infusion.

Our unique, open weave, TEFLON impregnated glass flow media (Taconic 7195) controls the flow front because it is thin, has modest permeability, and its fill fibers form flow

weirs. Besides controlling resin flow, the media works to solve a number of other issues. This media can withstand exposure to temperatures up to about 600°F and is chemically inert. It is free of contamination and has excellent release properties. It is readily available, has relatively low foreign object defect potential, and minimizes bag bulk because it is low profile. It reduces or eliminates mark off on the bag side of the laminate with its stiff but pliable nature.

One option to achieve improved flow control uses bagging materials with high elongation (over 500 %) and relatively low modulus, such as STRETCHLON 700 polyester and STRETCHLON 800 nylon bagging films. High elongation bagging materials make it easier to bag simple and complex preforms with relatively few bag wrinkles. Preform areas under bag wrinkles tend to have relatively high permeability and can result in undesirable resin channeling along those bag wrinkles. Therefore, minimizing bag wrinkles with high elongation bagging materials improves flow front control.

Another option uses gum rubber seals around the periphery of the part. With no edge seal or solid edge seals, channeling often occurs at the edges of the preform because of the high permeability that exists in the gaps typically found between the preform, bag, and solid seal. Using high elongation bags and gum rubbers seals together with/or without thermal vacuum cycles, a tight seal between the edge of the preform, bag, and seals can be achieved. The gum rubber moves viscoelastically to fill in all the gaps that otherwise exist at the irregular edge of a dry or binderized preform (i.e., a preform having fibers coated with or containing binder or tackifier). Gum rubbers seals have been found to be particularly useful when dealing with thick preforms where one has large bag discontinuities at the edge of the part. Bag bridging at these locations allows excessive channeling. Gum rubber seals, however, work to seal the edge effectively, ease the bag transition, and reduce the effects of edge tapering on the preform from bag stresses.

A double ended vacuum pull off technique successfully defeats channeling that may occur for any number of reasons. If resin channels along one edge of the part, the potentially "fatal" problem can be simply corrected by clamping the vacuum tube on

the channeled side and continuing the vacuum infusion with the opposite vacuum line in an active mode.

Another method proven to defeat channeling is to infuse preforms in an inclined orientation with the resin being fed at the lowest elevation and moving upwardly through the preform with vacuum through ports located at the highest elevation. With this method, gravity helps to maintain a constant fluid level in the preform and resists resin flow, at least partially. Some preforms, such as multi-axial warp knit preforms with bundled unidirectional fibers can have naturally occurring permeability variations that can cause poorer flow control than in preforms using more consistent materials such as 5 and 8 harness satin cloth.

A thermal vacuum cycle used prior to infusion also minimizes channeling. Here, the preform gets debulked (i.e., compressed while having air removed from between plies) to a thickness within about 10 % greater than its final thickness. Likewise, the bag's modulus drops at elevated temperature where it more easily elongates. As the bag elongates, it fits better and better to the underlying preform material, eliminating all but the most severe of bag bridges. In cases of severe bag bridging, as for example at discontinuities around tooling elements for bag side stiffeners, we use gum rubber seals either between the inner and outer bags or directly inside the inner bag at the discontinuity to help bridge the gap. Eliminating bag bridging avoids channeling and resin rich areas that would develop at the bridged sites.

We can reduce or essentially eliminate bag mark off with the use of semi-boardy, closely woven, TEFLON impregnated fiberglass materials such as Taconic 7195 or ChemFab CHEMGLAS 1589 as a separate ply and flow media. The low profile minimizes bulk and allows better contouring relative to several layers of glass cloth materials. The uniform, close weave construction of our flow media results in more uniform pressure application across the preform relative to knotty knit materials or bag offset materials. The low profile and weave uniformity of our flow media also makes it possible to use cauls or intensifiers effectively above the flow media to enhance part surface smoothness. The semi-boardy nature of the flow media works to buffer bag and breather wrinkles from transferring to the infused part even in the absence of pressure intensifiers or caul plates. When our flow media is used in conjunction with vacuum thermal cycles, high elongation bags, and gum rubber seals

around major discontinuities, mark off is substantially eliminated even on complex parts. Mark off can cause a local weakening of the composite caused by stress concentration.

In our process, an Airweave N-10 breather, between our inner and outer bag has a tendency to bridge over part discontinuities and to fold in areas of excess bulk. To achieve optimum fit between the part and the preform, the breather and the outer bag are placed over the inner bag with vacuum to seat the breather temporarily. The outer bag and the breather are removed. The breather usually is then, cut and darted to allow a perfect fit. The breather, elastomeric materials that form the outer bag, and the breather network can usually be reused.

Therefore, preferred embodiments of our process produce composites with low void contents, minimal surface porosity, excellent thickness control, and high fiber volume. The preferred process provides high vacuum integrity, eliminates resin channeling and poor wave front control. It greatly reduces bag side mark off. It reduces the plumbing complexity and improves manufacture of wide composites. Finally, our preferred process reduces resin waste.

VI. ISSUES

Claims 1, 4-8 and 10 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which Applicant regards as the invention.

Claims 1 and 6-8 are rejected under 35 U.S.C. 103(a) as being unpatentable over *Lang* (U.S. Patent 6,406,659) in view of *White* (U.S. Patent 5,427,725) and in further view of EP 0 816 438 A2 (Cytec), *Shepherd* (U.S. Patent 5,129,813) and *McClure* (U.S. Patent 6,090,335).

Claims 4-5 and 10 are rejected under 35 U.S.C. 103(a) as being unpatentable over *Lang* (U.S. Patent 6,406,659 B1) in view of *White* (U.S. Patent 5,427,725) and in further view of Cytec, *Shepherd* (U.S. Patent 5,129,813), *McClure* (U.S. Patent 6,090,335) and *Imanara* (U.S. Patent 5,364,584).

Claim 11 is rejected under 35 U.S.C. 103(a) as being unpatentable over *Lang* (U.S. Patent 6,406,659 B1) in view of *White et al.* (U.S. Patent 5,427,725) and in further view of

Cytec, *Shepherd* (U.S. Patent 5,129,813), *McClure* (U.S. Patent 6,090,335) and *Stoeberl* (U.S. Patent 4,120,632).

Claim 12 is rejected under 35 U.S.C. 103(a) as being unpatentable over *Lang* (U.S. Patent 6,406,659 B1) in view of *Stoeberl* (U.S. Patent 4,120,632).

VII. GROUPING OF CLAIMS

Each claim stands separately; arguments for the patentability of each claim appear in the Argument section.

VIII. ARGUMENT

Note that Word software wants to correct the spelling of “preform” to - - perform - -, so you might see typos of that nature in this argument.

Rejections based on §112, 2^d paragraph

Applicant respectfully traverses the rejection of claims 1, 4-8, and 10 based on §112. The claims need to be reasonably definite. The Examiner rejects the claims because certain terms are qualitative rather than quantitative, and he deems this language “relative,” uncertain, and indefinite. Again, the standard is reasonableness. The claims do not need to be precise.

The Examiner rejects claims 1 and 10 for reciting “low modulus” and “high elongation.” At page 12, lines 22-29, the specification identifies that high elongation equates to over 500% elongation, which makes it easier to bag simple and complex preforms with few wrinkles. Low modulus materials are described as those characterized by STRETCHLON 700 polyester or STRETCHLON 800 nylon bagging films. Accordingly, these terms are reasonably definite because of the definition that the specification provides for each. These definitions in the specification carry over to the claims, because the same words are used. The definitions need not be set forth explicitly in the claim because it is set forth adequately in the specification. A skilled artisan could use either of the two identified films to use the claimed process. The requirements of §112 are satisfied.

The Examiner also rejects claims 1 and 10 asserting that the term “modest” renders these claims indefinite. “Modest” appears in the context: “The flow media having modest

permeability, including fill fibers that act as weirs.” The specification focuses on control of the infusing flow front to achieve a suitable product. For example, at page 12, lines 3-16, the specification identifies that Taconic 7195 TEFLON impregnated glass is a preferred flow media that has “modest permeability.” The entire passage reads:

The key to successful infusions is not the speed with which the preform is infused, but rather the quality of the infusion. Maintaining a controlled wave front with lower permeability flow media over the preform gives cleaner infusions. The flow media we prefer to use should allow the resin to flow laterally slowly enough that the resin can uniformly drop down through the preform to wet out and completely fill the preform with a wedge shaped flow profile. In a controlled flow front, the resin front on the bag side of the preform is only 2 or 3 inches ahead of the resin front on the tool side of the preform assuming flow media is placed only on the bag side of the preform and infusion includes lateral flow through the media followed by downward flow to fill the preform. We prefer to control the relative permeability of the flow media to that of the preform to achieve this orderly, albeit relatively slow, infusion.

This description of a “modest permeability” makes the claim reasonably definite and satisfies §112. A skilled artisan would understand to use Taconic 7195 flow media to use the process.

The Examiner rejects claims 1 and 10 because “stiff but pliable” with respect to the flow media also is relative and, in his opinion, indefinite. As just described, the specification teaches a person to use Taconic 7195 for the flow media. At page 12, lines 20 and 21, the specification describes that “stiff but pliable” means that the flow media reduces or eliminates mark off on the bag side of the laminate. The claim language itself includes this function for the “stiff but pliable” flow media. The claims are reasonably definite and satisfy the requirements of §112.

Rejections based upon §103(a)

Applicant respectfully traverses the rejection of claims 1, 4 - 8, and 10 - 12 under §103(a) as being obvious. The references individually or collectively fail to describe a process that uses two vacuum bags for vacuum integrity and control of bag relaxation made from a material that also resists wrinkling in combination with a flow media of the specified characteristics to provide control of the flow front. Control of the flow front and laminate quality are key factors for making aerospace-grade composites. No reference teaches or suggests throttling the vacuum lines to achieve a matched mass flow rate, as claim 12 claims.

Claims 1 and 6, 7, & 8 are rejected based upon U.S. Patent 6,406,659 (*Lang*) in view of U.S. Patent 5,427,725 (*White*) in further view of EP 0 816 438 (Cytec), U.S. Patent 5,129,813 (*Shepherd*) and U.S. Patent 6,090,335 (*McClure*). A skilled artisan would not combine these five references in the manner the Examiner asserts without using hindsight based upon Applicant's own teaching, because these references fail to teach or to suggest the alleged combination. They only are combined because Applicant has determined and taught others to do so to provide a reliable vacuum-assisted resin infusion process. The process of the present invention allows the manufacture of aerospace quality composite parts having a high fiber volume fraction.

Lang describes a composite molding method and apparatus. The Examiner asserts that *Lang* teaches placing a preform on a mold surface, double bagging over the preform, vacuum debulking, and vacuum-assisted resin transfer molding. *Lang* teaches the creation of temporary resin distribution channels on the surface of the preform to aid distribution of the infusing resin. These channels are essentially wrinkles in the bag or bridges that deplete the preform of resin by becoming resin-rich areas and which also produce markoff on the bag side. In the present invention, steps (d) and (e), Applicant teaches to avoid bag wrinkles and to avoid bag-side markoff. *Lang*, accordingly, teaches away from what Applicant teaches.

Lang does teach the use of two vacuum bags, but uses them in a mystifying way that is counterproductive to a successful infusion in several ways. *Lang* places a spacer in the cavity between the two bags over the preform. He draws a vacuum in this cavity such that higher pressure outside the bags (i.e., the atmosphere) and inside the cavity that surrounds the preform causes stretching of the inner bag and the formation of distribution channels inside the inner bag over the preform. For these channels to develop – they are essentially induced wrinkles in the inner bag – the pressure in the cavity that holds the preform must be significant relative to the pressure in the cavity that holds the spacer. With the pressure relatively high in the preform cavity, the pressure difference between the resin pot and the preform cavity is relatively low, and the driving force for infusion of the resin also is low.

Lang does not use flow media inside the preform cavity, as required in step (e) of the present invention. It would be superfluous to use both the spacer and double bag and the flow media, so a skilled artisan would not follow the teachings of *Lang*, if he were performing the present invention. Following *Lang* and using both a spacer and flow media would increase

the cost and labor and would provide two elements to perform the same function. No one would do that. Nothing in *Lang* or the secondary references teach or suggest the departures that the Examiner makes to *Lang*. Using the temporary distribution channels would require the flow of resin over the entire surface before significant resin would infuse into the preform. There would be a loss of the flow front control that Applicant deems critical to achieve a reliable infusion needed to produce aerospace quality composite parts. After the distribution channels are eliminated, there is no driving force to press the resin into the preform, and we suspect that *Lang* would produce parts having voids or porosity because resin would reach the vacuum outlet before completely filling the preform with a steadily progressing, controlled flow front, as contemplated in the present invention. *Lang* does not have fill fibers in the flow media in the inner bag to act as weirs to the infusion resin.

Lang does not tackify the perform and does not vacuum debulk..

White describes a process for resin transfer molding and a preform used in the process. *White* tackifies a preform to make it shapeable, adds a matrix resin and co-cures the tackifier and resin. *White* does not mention vacuum-assisted resin infusion. Applicant did not invent tackifying, but *White* fails to teach that tackifying can or should be used in a vacuum-assisted resin infusion process. *Lang* does not suggest its use either, so no one would combine *Lang* and *White* in the manner that the Examiner has.

The Examiner asserts that it is logical to combine *Lang* and *White* because *White* teaches that tackified preforms allow making of net shape composites by allowing stacking of individual layers. Of course, neither *Lang* nor *White* indicate that there is any problem with stacking the tackifier-free layers in *Lang* to make a flat panel, so there is no motivation from either reference to make the change in *Lang* that the Examiner suggests. *Lang* is content to make his composites without tackified preforms, especially when *Lang* does not have any net shaping issues to deal with. *Lang* and *White* are combined solely because what Applicant has taught rather than from any logic in the references themselves. The Examiner applies hindsight. Furthermore, Applicant uses a tackifier that toughens the composite to improve its damage tolerance. *White* fails to teach to suggest such a tackifier. He simply wants the preform layers to stick together during the layup. There is no reason to combine *Lang* and *White*, but, even if you do, you do not get what Applicant teaches and claims.

Cytec describes tackified prepreg systems that make a toughened composite. Cytec uses a non-toughening, elastomeric tackifier, and, therefore, teaches away from what Applicant describes and claims. Cytec achieves toughening in the composite by using a toughening amount of a particulate engineering thermoplastic blended into the resin and impregnated onto the tackified fabric to form a prepreg. Cytec teaches away from the present invention by suggesting the use of thermoplastic particulates mixed with the resin to achieve the toughening and in teaching the need to use a prepreg rather than a preform. If one were to substitute what Cytec teaches for *White* and to carry that back into *Lang*, the resin would already be inside the vacuum bags and there would be no need for infusion. Accordingly, no one would combine these references because what they teach clashes. Applicant claims a toughening tackifier, anyway, rather than a non-toughening tackifier in combination with a toughening amount of a particulate engineering thermoplastic. There is no sense to the rejection in the Examiner's assertion to combine Cytec with *Lang* and *White*. Doing that fails to suggest the steps that Applicant claims and leads to a cobbled mess. Skilled artisans do not go from reference to reference picking isolated and disparate teachings and elements from each without clear direction that one is a substitute for another or that one will solve a problem understood to plague another. That is not the situation with these references, and no one would combine them without resorting to what Applicant has taught.

Resin infusion in the present invention is designed to replace the use of prepregs which are expensive to make, expensive to store, and short lived because the resins react while in storage, even when frozen.

Shepherd describes embossed vacuum bag, methods for producing and using the bag. The Examiner asserts that *Sheppard* teaches using a low modulus, high elongation nylon vacuum bag, and concludes, then, that it is logical to use it in the manner that Applicant claims in conjunction with Cytec, *Lang* and *White*. Applicant does not claim to have invented low modulus, high elongation vacuum bags. Applicant's invention is a method that uses such bags to produce aerospace composites. The novelty in Applicant's invention resides in the method steps used rather than in Applicant discovering a new material that can be used in a conventional process. *Sheppard* discusses bag relaxation, which is probably why the Examiner cited it. The essential feature of the *Sheppard* bag, to achieve its objects, however, is that it has impressed on it a 3-D pattern which defines a plurality of interconnected

channels (col. 2, lines 56 – 61). Applicant does not use such a bag material. The *Sheppard* bag may have the low modulus and high elongation attributes, because it relaxes to form a fully conformal surface over the layup - - *Sheppard* uses prepregs - -, but *Sheppard* fails to cure all the deficiencies of *Lang*, *White*, and Cytec.

McClure describes a process of forming fiber reinforced composite articles using an in situ cured resin infusion port. It fails to overcome the deficiencies in the rejection that Applicant has raised with respect to *Lang*, *White*, and the other cited references. The Examiner asserts that *McClure* teaches the use of resin flow media. If that is true, as Applicant pointed out earlier, the skilled artisan would not use the flow media in *Lang* because *Lang* creates resin distribution channels in the bagging material and does not want or need flow distribution media. Using it in *Lang* would increase waste and cost. Therefore, the Examiner cites *McClure* purely by the application of hindsight based upon Applicant's own teaching. He sees that the claim requires flow media, so he has found a patent that uses it. It is illogical, however, to use *McClure's* flow media with *Lang's* system insofar as going so provides two elements to perform the same function when either one would do fine along.

The Examiner refers to discussion of what *McClure* characterizes as the prior art as *McClure's* teaching or suggestion to use flow media. The flow media is described as a cloth which tends to wick the resin to facilitate resin flow. *McClure* actually teaches not to use such flow media because it requires labor to place it, specialized procedures for disposal and clean-up, and added time. Further, *McClure* describes a cloth that facilitates flow while Applicant claims a flow media having weirs (i.e. dams) that inhibits flow.

The combination of references asserted by the Examiner fail to teach or to suggest the method steps recited in claims 1, 6, 7, or 8. The cited references do not suggest using a tackifier containing toughening agents. They do not suggest using two, low modulus, high elongation vacuum bags to minimize bag wrinkles. They do not suggest an open weave flow front by having fill fibers act as weirs. They do not suggest a stiff but pliable flow control media to prevent bag side mackoff. They do not together suggest infusing the resin through the flow media. Because the combined references lack all these limitations of claim 1, the rejection for obviousness must be withdrawn.

The rejection should also be withdrawn simply by recognizing that the skilled artisan would never combine teachings from five different references.

With respect to claim 6, the Examiner asserts that *White* tackifies the preform at elevated temperature and, then, impregnates the preform with resin while the preform is hot. Claim 6, however, specifies that the inner vacuum bag is applied when the preform is at an elevated temperature. *White* does not suggest this step.

With respect to claim 7, the Examiner asserts that *White* also teaches partially curing the tackifier before infusing resin. Claim 7, however, recites that vacuum debulking occurs at an elevated temperature. *White* does not discuss vacuum debulking so it cannot suggest doing it at an elevated temperature.

The action is confusing because it refers first to *White* and, then, reverts to *Lang*. *Lang* does not suggest vacuum debulking, although it does teach evacuating the cavity around the preform prior to introducing resin to avoid entrapping air bubbles in the resin. Of course, if this cavity is evacuated and so, too, is the cavity that holds the spacer, there is no driving force to create the temporary resin distribution channels. Therefore, *Lang* is internally inconsistent in what it teaches. In any event, it does not teach vacuum debulking at an elevated temperature.

With respect to claim 8, the Examiner asserts that *Lang* teaches use of carbon fiber and epoxy resin and that *White* teaches an epoxy resin tackifier. The selection of materials, however, does not overcome the deficiencies of all the references with respect to the method steps of claim 1.

Claims 4, 5, and 10 are rejected based upon *Lang*, *White*, *Cytec*, *Shepherd*, *McClure*, and U.S. Patent 5,364,584 (*Imanara*). *Imanara* describes a process for producing fiber-reinforced resin moldings, including slanting a mold 15-90 degrees prior to and during resin infusion.

Claims 4 and 5 depend from claim 1 and are patentable because of the deficiencies already noted with respect to *Lang*, *White*, *Cytec*, *Sheppard*, and *McClure*. While *Imanara* suggests tilting the preform, it does not overcome all the other noted deficiencies.

Claim 10 is an independent claim that requires use of an open weave, modest permeability flow control media having fill fibers that act as weirs to resist resin infusion in conjunction with tilting the preform. Applicant has already argued that *Lang* and the other references cited with respect to claim 1 fail to teach or to suggest such a media or flow control step. *Imanara* teaches structural reaction injection molding (SRIM) in matched dies at high

injection pressure. *Imanara* does not use a flow control media, especially one whose purpose is to resist flow of resin. *Imanara* is inapplicable to what claim 10 requires because *Imanara* is SRIM rather than a vacuum-assisted resin transfer molding process. It in combination with the other references still fails to teach a flow media with fill fibers acting as weirs to achieve improved control of the resin wavefront in a bagged preform.

Claim 11 is rejected based upon *Lang*, *White*, *Cytec*, *Shepherd*, *McClure*, and U.S. Patent 4,120,632 (*Stoeberl*). *Stoeberl* describes molds for producing plastic boats in matched dies. *Stoeberl* teaches “passages [that] are effective to relieve foam that is pumped into the mold cavity between the mold halves..., allowing air to escape from the mold cavity while throttling the air released to build up back pressure or to create a suction effect.” Claim 11 requires throttling the vacuum lines to control the mass flow rate of resin. *Stoeberl* fails to teach or to suggest this step. Claim 11 also is patentable because the other references fail to teach or suggest what Applicant recites as the process steps in claim 1, as previously argued.

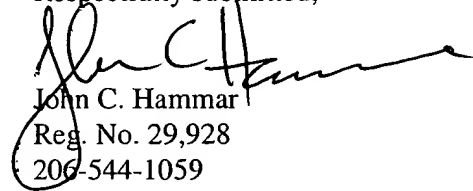
Claim 12 is rejected for obviousness over *Lang* in view of *Stoeberl*. Claim 12 requires in a vacuum-assisted resin transfer molding process, throttling the vacuum lines to achieve a mass flow rate of resin into a debulked preform at a rate where the in/through the preform is substantially equal to the rate in the vacuum lines. That is, the throttling means that resin entering the cavity does not pool or accumulate in the flow media because the same mass that is entering in a period of time is the same mass that is infusing into the preform.

Lang double bags, but does not teach a debulked preform. *Lang* does not throttle. It feeds the resin directly into the preform or, originally, entirely into the temporary resin distribution channels. In neither case does *Lang* suggest what Applicant claims.

Stoeberl teaches throttling to create a back pressure. *Stoeberl* does not discuss equilibrating the mass flow rate into the cavity with that in the preform. *Stoeberl* does not have flow media where pooling could occur and only has fibrous sheets on the surfaces of the mold cavity rather than as a preform. The body of *Stoeberl*'s boat is largely unreinforced.

Accordingly, *Stoeberl's* throttling does not overcome the deficiencies of *Lang* and the combined references fail to teach or to suggest the invention of claim 12.

Respectfully submitted,



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206-544-1059

IX. APPENDIX

The appealed claims are:

1. A vacuum-assisted resin transfer molding process for making a laminate, comprising the steps of:
 - (a) assembling a preform from suitable reinforcement, in a mold;
 - (b) tackifying the preform with a tackifier containing toughening agents for improved damage tolerance in the mold to produce a tackified preform;
 - (c) vacuum debulking the tackified preform;
 - (d) double bagging the debulked preform with an inner bag and outer bag using high elongation, low modulus nylon bagging films to control bag relaxation and to improve vacuum integrity while minimizing bag wrinkles;
 - (e) enclosing an open weave flow control media between the inner bag and the debulked preform to control the flow front during resin infusion, the flow media having modest permeability, including fill fibers that act as weirs to an infusing resin, is able to withstand exposure to temperatures up to about 600°F, is chemically inert, and is stiff but pliable to eliminate markoff on the bag side of the laminate; and
 - (f) infusing resin into the debulked preform through the flow media using a vacuum-assisted resin transfer molding process.
4. The improvement of claim 1 further comprising the step of infusing the resin into the preform tilted at an angle off horizontal.
5. The process of claim 1 wherein infusion occurs with the preform tilted at an angle off horizontal so that gravity at least partially opposes flow of the resin into the preform.
6. The process of claim 1 wherein the inner bag is applied to the preform at an elevated temperature.

7. The process of claim 1 wherein vacuum debulking occurs at an elevated temperature to better bind the tackified preform together.
8. The process of claim 1 wherein the reinforcement is carbon fiber, the tackifier is a plasticized epoxy, and the resin is epoxy.
9. A process for controlling bag relaxation behind the wavefront in a vacuum-assisted resin transfer molding process wherein resin is infused from a source at atmospheric pressure into a preform in an environment under a vacuum bag at a controlled pressure below atmospheric pressure, comprising the step of:
applying a breather and second vacuum bag over the original vacuum bag.
10. An improved vacuum-assisted resin transfer molding process for infusing resin into a preform, the improvement comprising:
introducing resin to a flow media at the lowest point in the bagged preform assembly so that infusing resin flows against gravity through the flow media and preform, thereby providing improved control of the wavefront by higher resistance to flow than with horizontal infusion, the flow media having an open weave, having modest permeability, including fill fibers that act as weirs to the infusing resin, is able to withstand exposure to temperatures up to about 600°F, is chemically inert, and is stiff but pliable to eliminate markoff on the bag side of the laminate.
11. The process of claim 1 further comprising the step of throttling vacuum lines connected in fluid communication with the double bagging so that the mass flow rate of resin through the debulked preform substantially equals the mass flow rate of resin in the vacuum lines.
12. In a vacuum-assisted resin transfer molding process, the improvement comprising:

throttling vacuum lines connected in fluid communication with double bagging surrounding a debulked preform so that the mass flow rate of resin through the debulked preform substantially equals the mass flow rate of resin in the vacuum lines.